Cowpea living mulch effect on soil quality and grain yield in smallholder maize-based cropping system of northern Ghana

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Outline of presentation

Introduction

- Background
- Problem statement
- Justification and objective

Methodology

- Study area
- Experimental design and treatment
- Soil quality indexing

Results

- Cowpea living mulch effect on soil properties and soil quality
- Cowpea living mulch effect on maize grain
- Relationship between maize gain yield and soil quality
- Implications of the results on cowpea living mulch technology

Conclusions

Introduction

Background

- Maize is a major staple in northern Ghana.
- It is produced on subsistence basis with 77-94% of the total land area under maize cultivation been < 2 ha of land (Amanor-Boadu et al., 2015)
- It is produced under rainfed condition with an average yield of < 2 t/ha compared with a potential of 6 t/ha (MoFA, 2017).

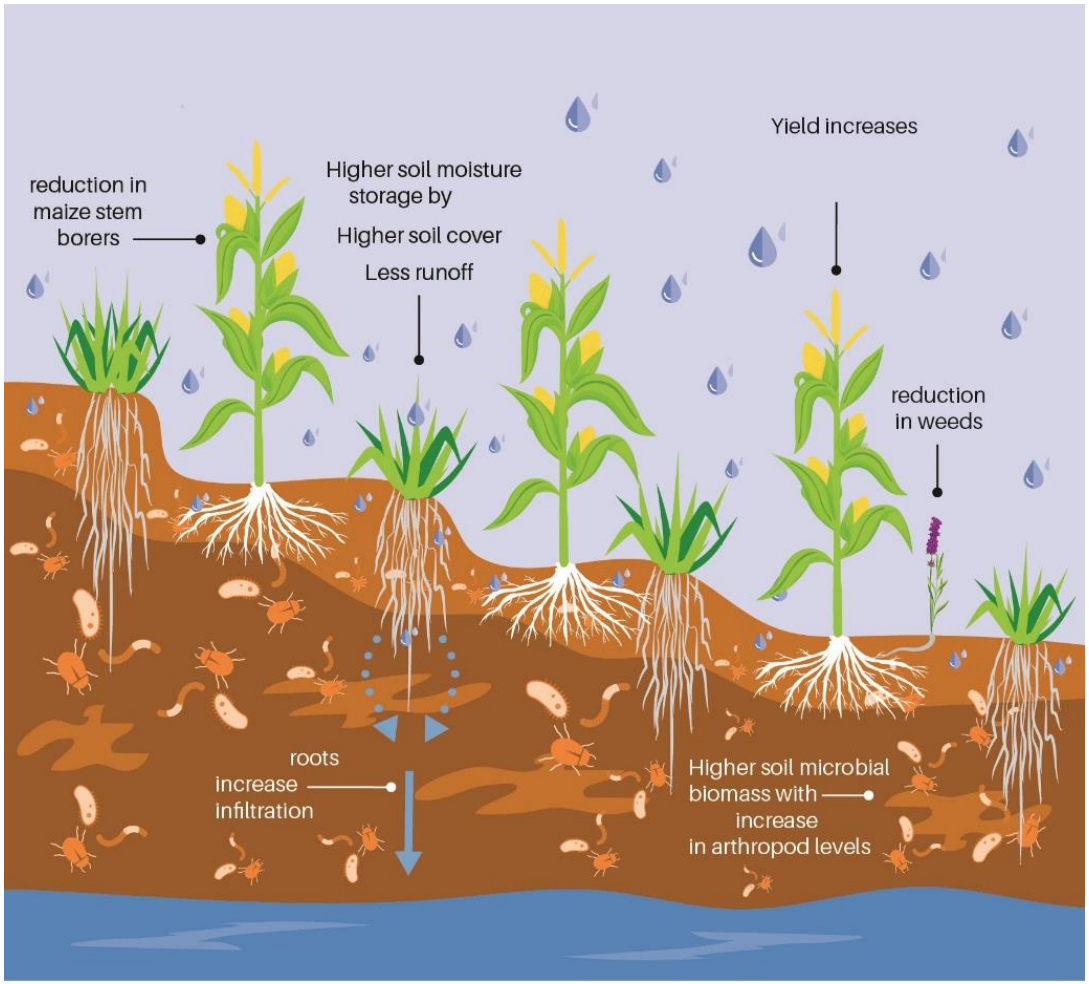
Problem statement

Low and erratic rainfall, low and diminishing soil fertility and weed infestation among key factors responsible for the yield gap.

Living mulch is a cover crop planted either before, same day with or after the main crop and maintain as groundcover throughout the cropping season or longer (Hartwign & Ammon 2002).

Introduction….

Benefits of food or feed legume living mulch



Introduction….

Cowpea living mulch technology

Introduction….

Justification/ knowledge gap

- Conflicting reports on the effect of living mulch on grain yield of main crops (Jędrszczyk et al., 2005; Radicetti et al., 2018; Jamshidi et al., 2013; Trail et al., 2016; Bhaskar et al., 2018)
- Limited quantitative data on effect of legume living mulch on grain yield and soil quality in smallholder maize-based cropping system in West Africa.

Research question

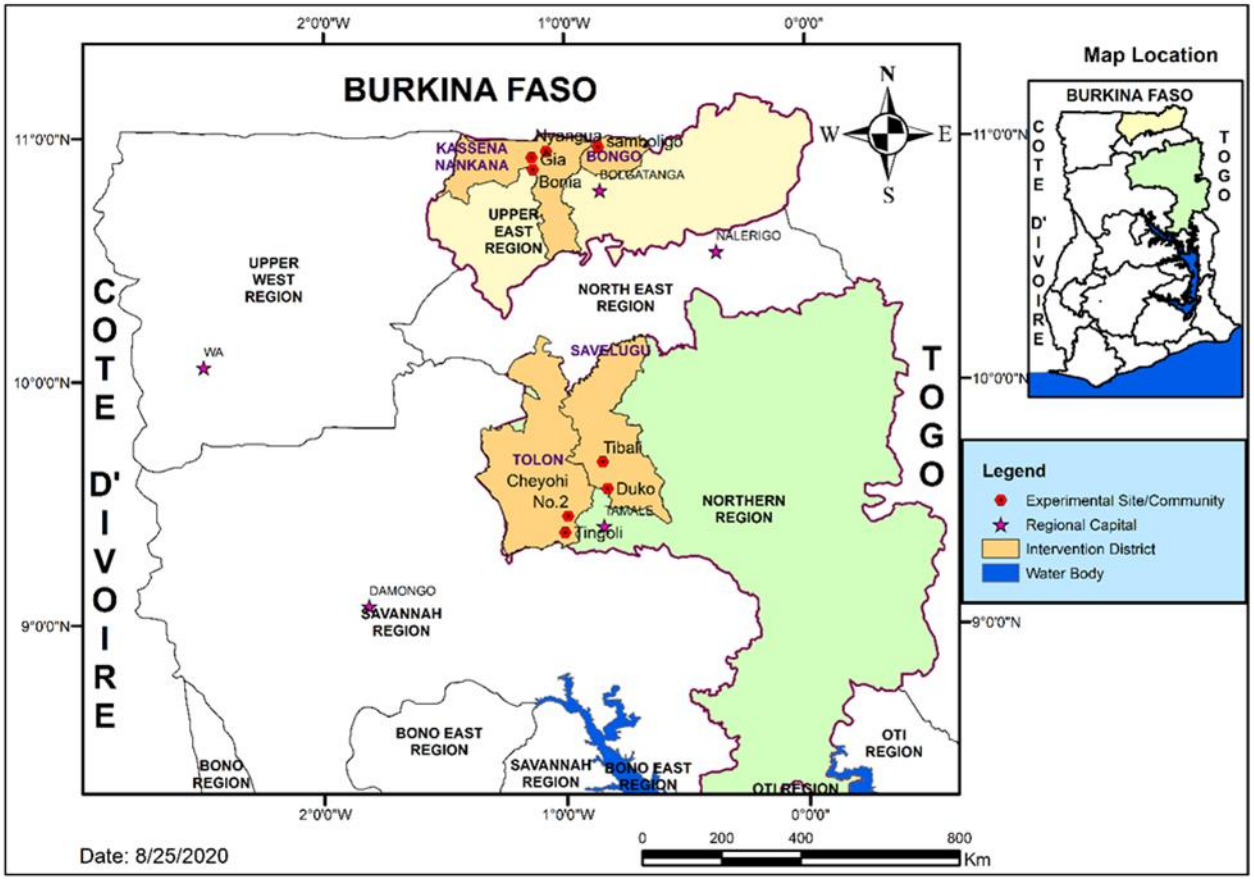
How would the time of planting cowpea as living mulch in smallholder maize-based cropping system affect grain yield and soil quality?

Objective

To determine the effect of cowpea living mulch on the grain yield and soil quality in smallholder maize-based copping system.

Methodology....

Study Area



Methodology....

Field layout with experimental design and treatments

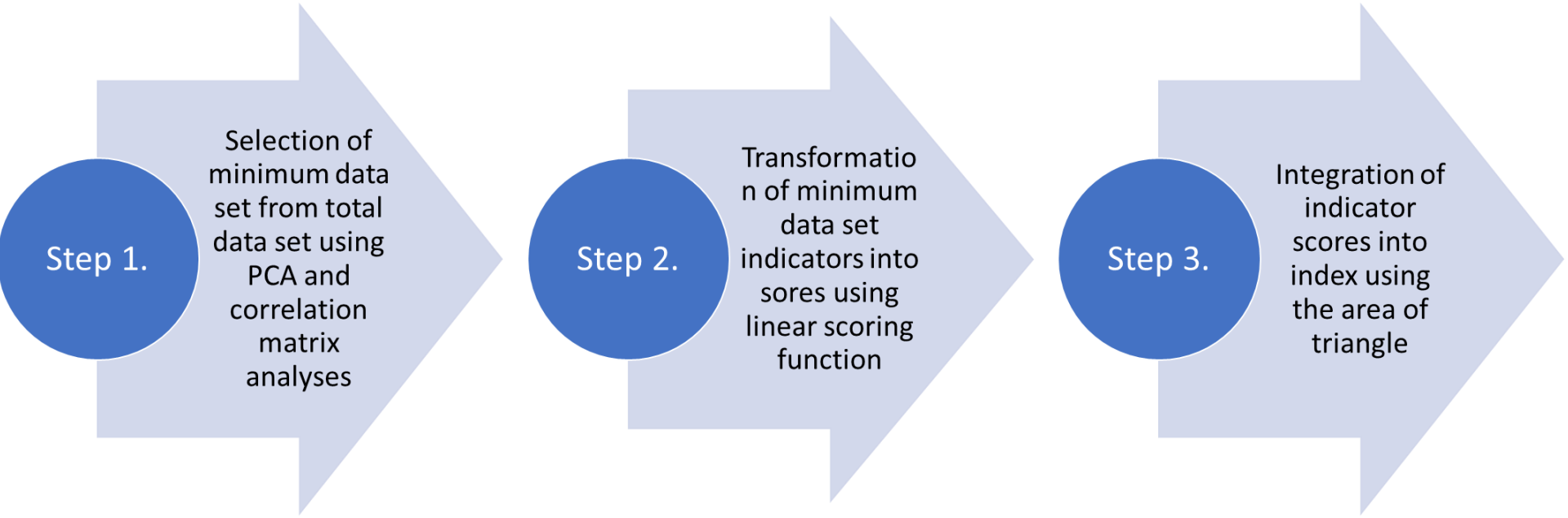
Extra-early	Early	Medium	
Plot 1	Plot 2	Plot 3	No living mulch
1m			
Plot 4	Plot 5	Plot 6	Cowpea living mulch + maize same day
1m			
Plot 7	Plot 8	Plot 9	Cowpea living mulch 1 week after maize
1m			
Plot 10	Plot 11	Plot 12	Cowpea living mulch 2 weeks after maize

5 m

4.5 m

Methodology….

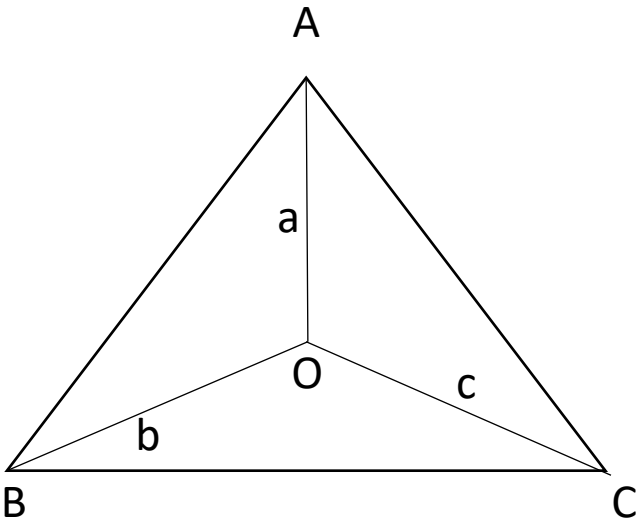
Soil quality indexing



(Abdul Rahman et al., 2019)

Methodology….

Soil quality indexing….



SQI = Area of △ABC

= Area of △AOB + Area of △BOC + Area of △AOC

$= \frac{1}{2}$ ab sin120°+ $\frac{1}{2}$ bc sin120°+ $\frac{1}{2}$ ac sin120°

$= \frac{1}{2}\sin 120°\,(ab+bc+ca)$

$= \frac{\sqrt{3}}{4}(ab+bc+ca)$ (Kang et al., 2005)

Methodology…

Measured soil parameters

Properties	Indicator	Scoring function
Physical	Soil temp. @ vegetative, tasseling and harvest stages of maize	Less is better
	Soil moisture @ vegetative, tasseling and harvest stages of maize	More is better
	Bulk density @ vegetative, tasseling and harvest stages of maize	Less is better
Chemical	pH	More is better
	Total carbon	More is better
	Total nitrogen	More is better
	Available phosphorus	More is better
Biological	Microbial biomass carbon	More is better
	Microbial biomass nitrogen	More is better
	Microbial quotient	More is better

Results

Soil temperature (℃) as affected by cowpea living mulch system (soil physical property)

	Norther Region						Upper East Region					
	Vegetative		Tasseling		Harvest		Vegetative		Tasseling		Harvest	
Living mulch	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
Control	29.1	29.1	28.2	29.4	30.9	33.1	33.2	28.7	29.7	30.2	38.1	29.7
MCSD	28.0	27.8	27.1	28.3	29.5	32.6	31.2	27.4	28.1	29.5	33.6	27.7
MC1W	28.3	28.4	27.6	28.6	29.8	31.4	31.3	28.0	28.6	29.3	34.4	27.6
MC2W	28.6	28.8	28.0	28.9	30.1	31.3	31.2	28.1	29.0	29.0	35.3	27.6
s.e.m	0.13	0.13	0.12	0.12	0.20	0.32	0.37	0.11	0.18	0.16	0.36	0.17
Contrast P-values												
Control vs Mulch	**	**	**	**	**	**	**	**	**	**	**	**
MCSD vs Week(s)	**	**	**	**	ns	**	ns	**	**	ns	**	ns
1W vs 2W	ns	*	*	ns	ns	ns	ns	ns	ns	ns	ns	ns

*P < 0.05

**P < 0.01

nsP > 0.05

Soil moisture (cm^3/cm^3 $x10^{-2}$) as affected by cowpea living mulch system (soil physical property)

	Northern Region						Upper East Region					
	Vegetative		Tasseling		Harvest		Vegetative		Tasseling		Harvest	
Cowpea living mulch	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
Control	8.3	3.0	5.8	2.8	6.6	3.4	4.0	6.8	4.2	3.9	3.8	3.7
MCSD	8.6	5.6	9.7	5.7	8.7	5.3	5.9	7.5	7.2	7.2	6.2	4.1
MC1W	8.4	5.2	8.2	6.0	8.1	5.4	5.8	7.1	6.9	6.9	4.4	3.8
MC2W	8.8	5.5	9.6	5.7	7.6	4.8	6.4	6.9	8.8	7.4	7.9	5.5
s.e.m	0.41	0.30	0.63	0.41	0.51	0.26	0.42	0.31	0.72	0.40	0.92	1.00
Contrast P-values												
Control vs Mulch	ns	**	**	**	**	**	**	ns	**	**	*	ns
MCSD vs Week(s)	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
1W vs 2W	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	**	ns

*P < 0.05

**P < 0.01

^{ns}P > 0.05

Cowpea living mulch effect on soil chemical properties

	Northern Region				Upper East Region			
	Total C (g/kg)		Total N (g/kg)		Total C (g/kg)		Total N (g/kg)	
Living mulch system	2017	2018	2017	2018	2017	2018	2017	2018
Control	4.8	5.5	0.5	0.6	4.5	4.4	0.6	0.6
MCSD	6.2	6.5	0.7	0.7	5.4	5.3	0.7	0.7
MC1W	5.9	7.1	0.7	0.7	5.6	5.5	0.8	0.7
MC2W	6.1	6.9	0.6	0.7	5.5	5.1	0.7	0.8
s.e.m	0.32	0.24	0.03	0.03	0.23	0.23	0.04	0.03
Contrast P-values								
Control vs Mulch	**	**	**	**	**	**	**	**
MCSD vs Week(s)	ns	ns	ns	ns	ns	ns	ns	ns
MC1W vs MC2W	ns	ns	ns	ns	ns	ns	ns	ns

**P < 0.01

^{ns}P > 0.05

Cowpea living mulch system effect on soil biological properties (microbial biomass, g/kg)

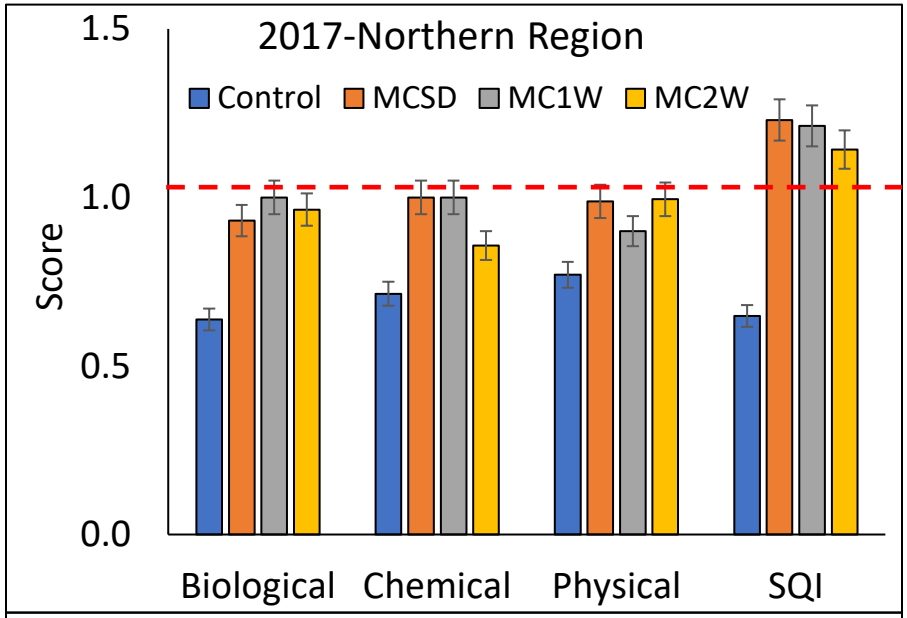
	Northern Region				Upper East Region			
	Carbon		Nitrogen		Carbon		Nitrogen	
Living mulch system	2017	2018	2017	2018	2017	2018	2017	2018
Control	111.3	117.5	12.0	19.6	87.4	88.1	17.2	12.6
MCSD	162.5	169.4	25.4	36.1	132.6	135.0	23.7	27.0
MC1W	174.5	173.1	31.8	49.1	133.8	149.3	22.8	31.1
MC2W	168.2	192.9	29.9	44.5	135.1	163.1	28.5	22.9
s.em	6.27	9.09	4.06	5.18	4.02	7.51	2.30	3.29
Contrast P-values								
Control vs Mulch	**	**	**	**	**	**	**	**
MCSD vs Week(s)	ns	ns	ns	ns	ns	*	ns	ns
MC1W vs MC2W	ns	ns	ns	ns	ns	ns	ns	ns

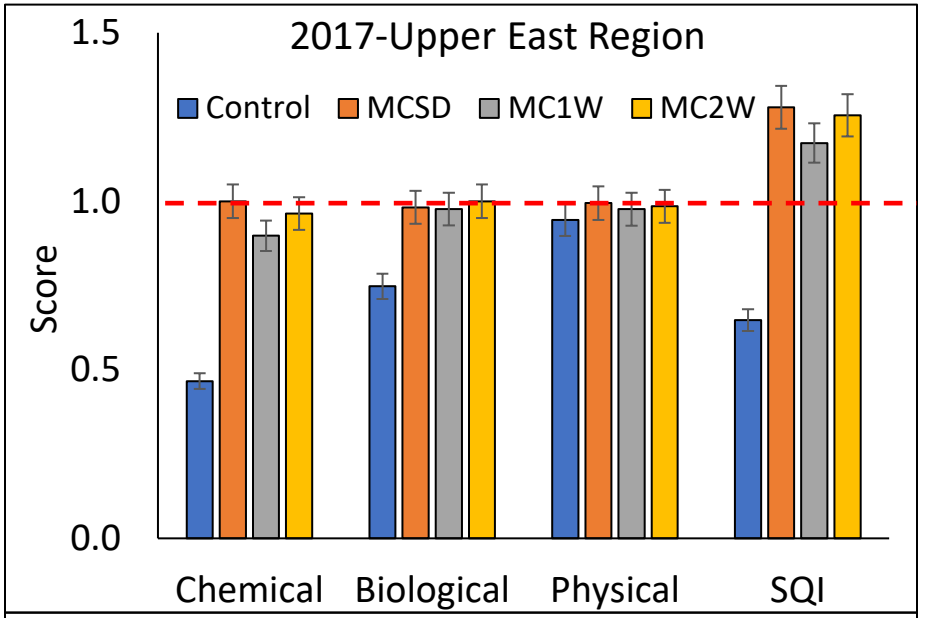
*P < 0.05

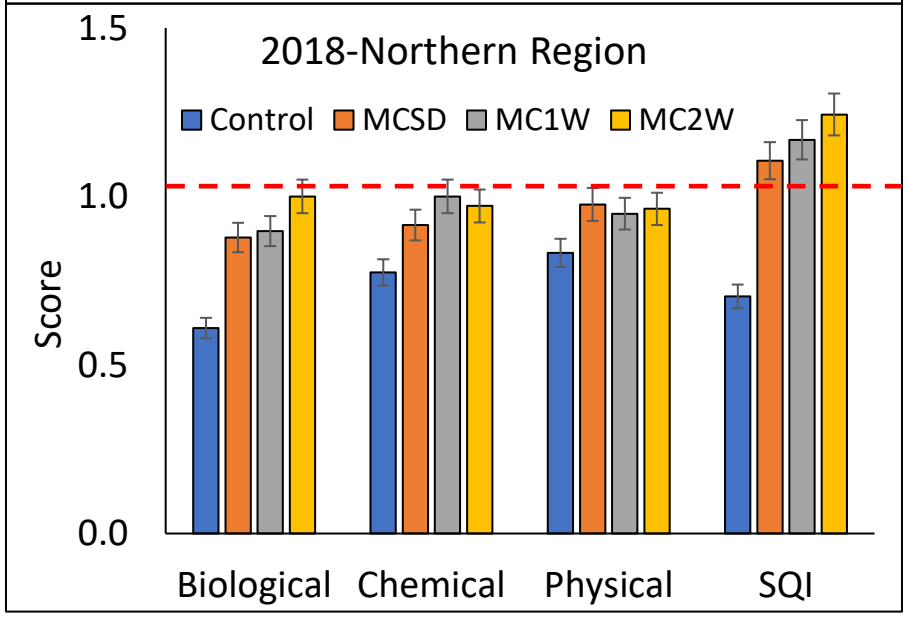
**P < 0.01

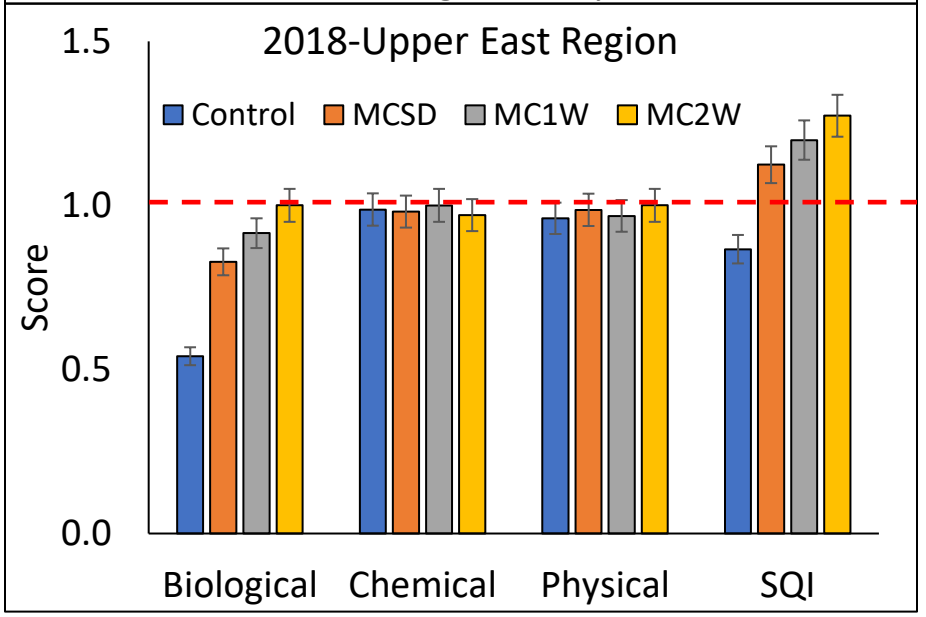
^{ns}P > 0.05

Cowpea living mulch effect on soil quality index

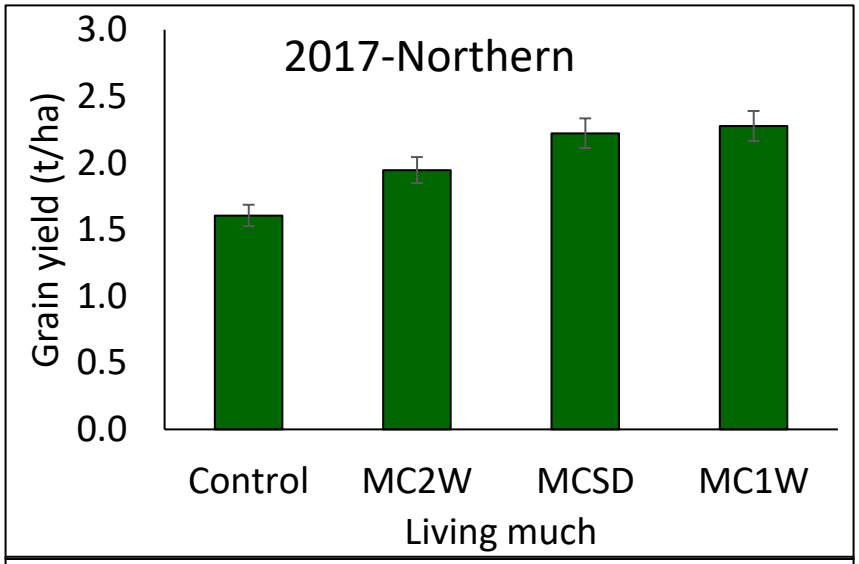


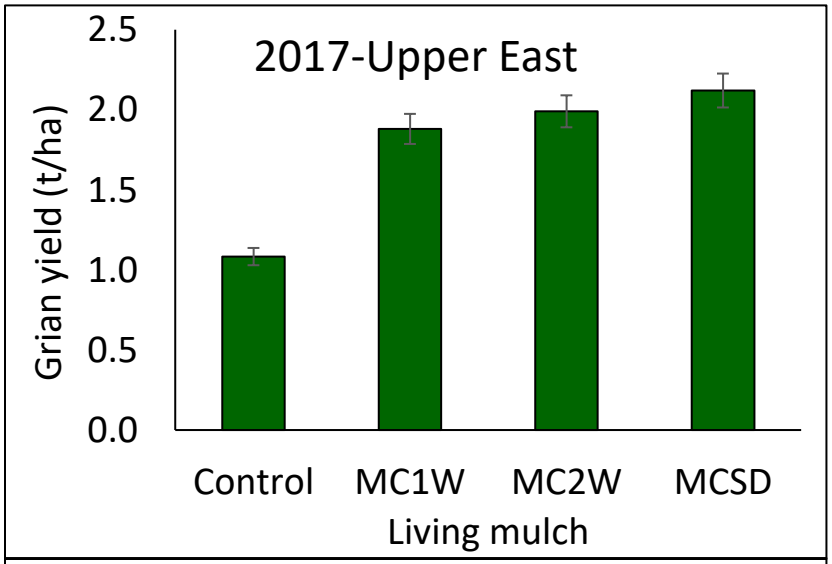


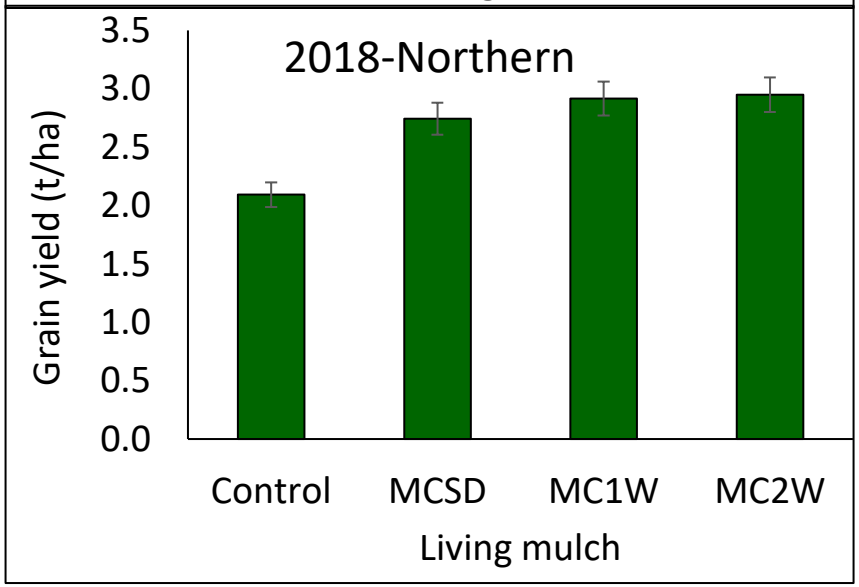


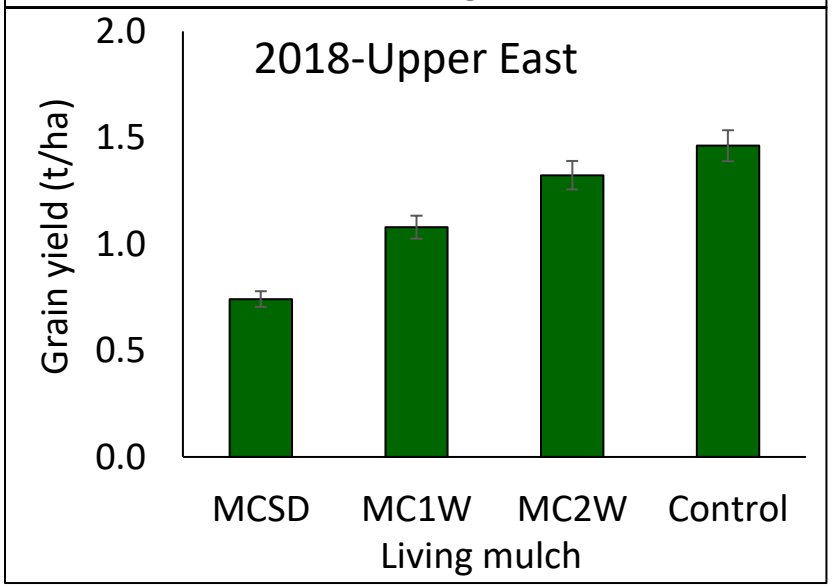


Maize grain yield as affected by cowpea living mulch system

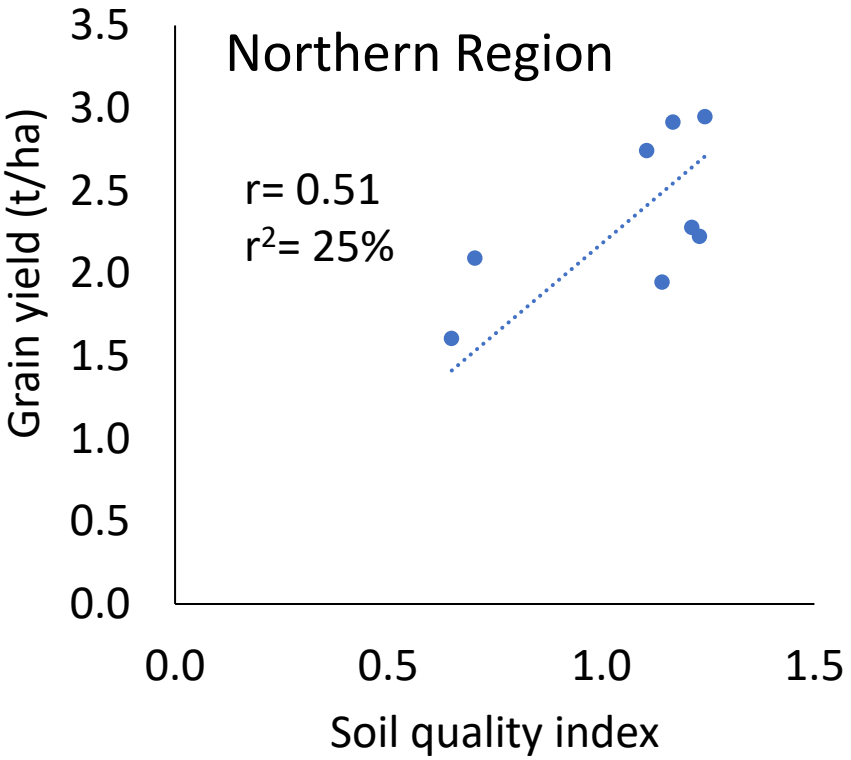


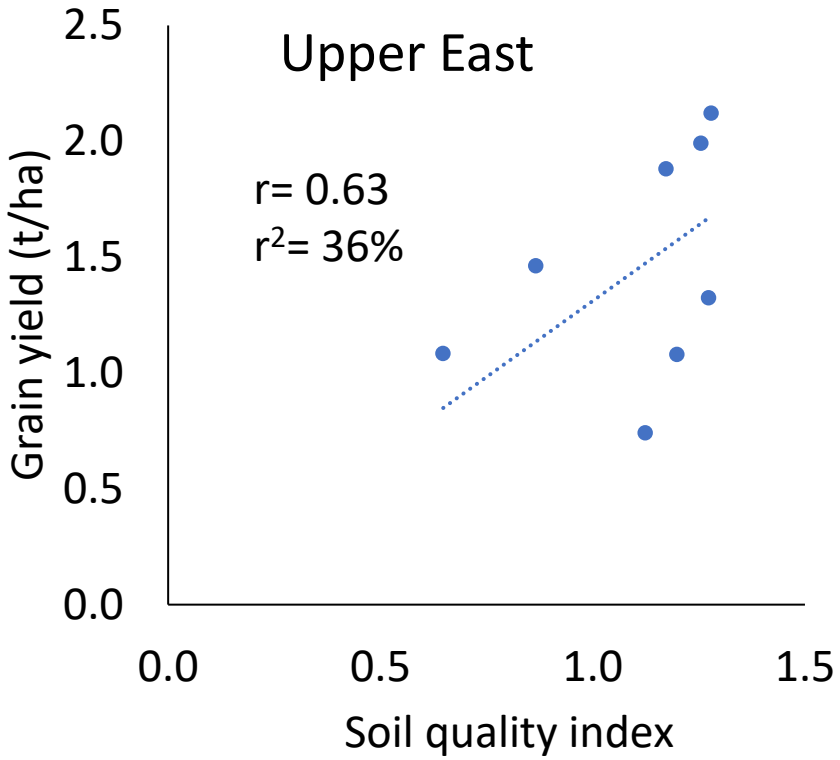






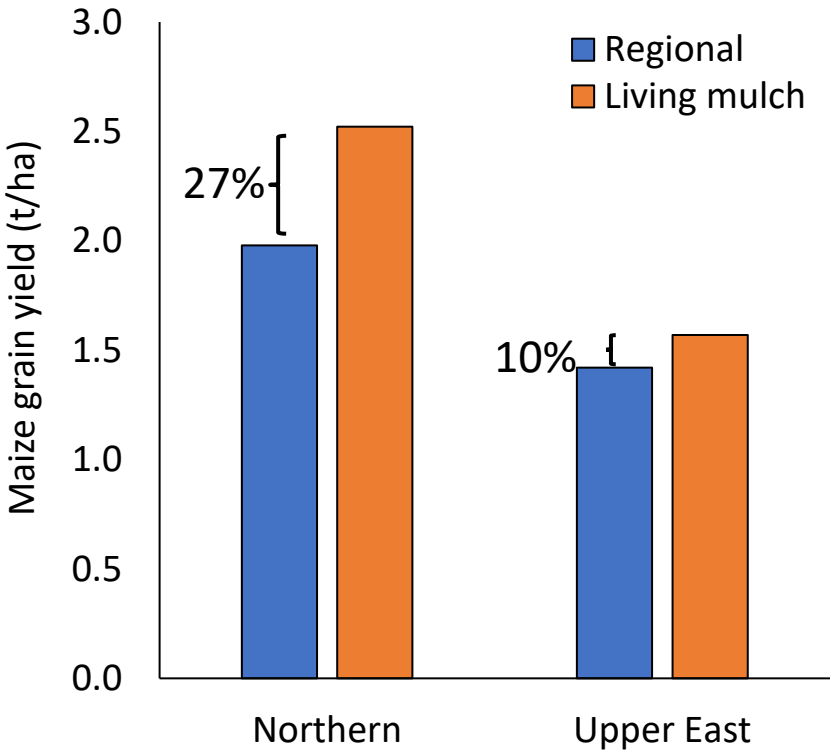
Correlation between maize grain yield and soil quality index



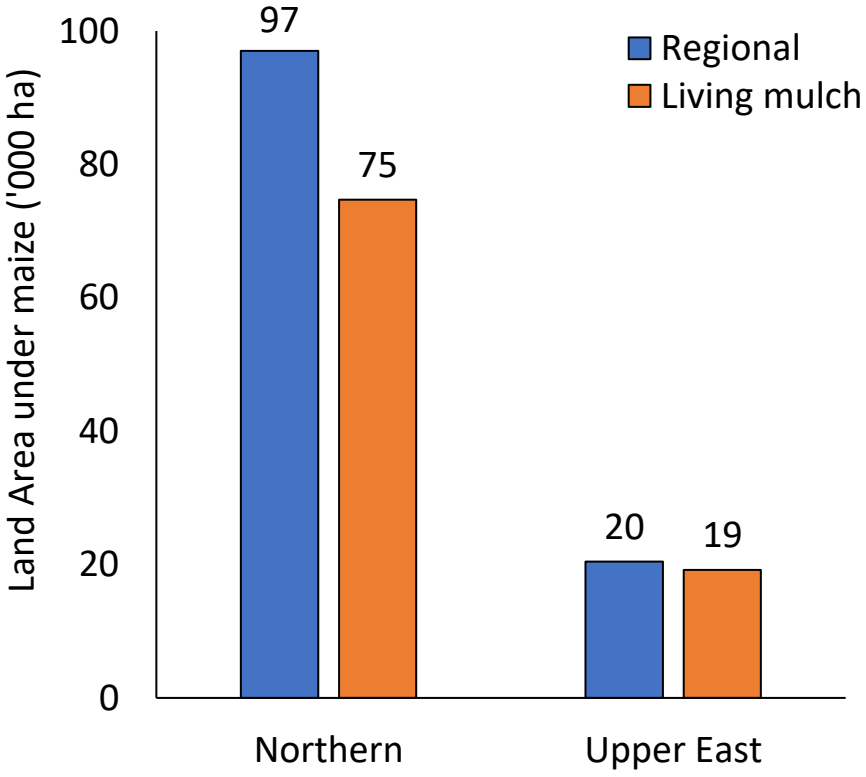


Implications of cowpea living mulch technology

Regional maize grain yield vs cowpea living mulch maize grain yield



Scaling out potential of cowpea living mulch technology



Conclusions

- Cowpea living mulch system significantly improved soil properties and SQI.
- It increased maize grain yield relative to that of the control treatment.
- Smallholder maize-based farmers can intercrop cowpea as living mulch at 1-2 weeks after planting maize to increase maize grain yield and soil quality.
- The methodology used in assessing the SQI provides a framework for soil quality assessment.

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